Brain tissue segmentation on Diffusion Weighted Magnetic Resonance data

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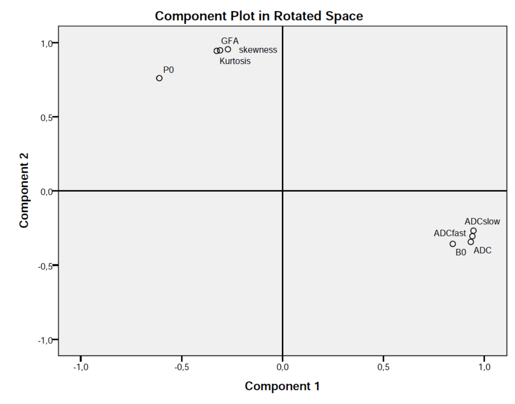
Motivation

- Application framework: fiber tracking
- DWI clinical practice: cerebral ischemia, epilepsy, MS, etc.
- DWI challenges:
  - Resolution
  - Low SNR, eddy currents, motion artifacts, signal loss & warping
- Why DWI segmentation?:
  - DWI-derived data is widely available
  - Avoid EPI unwarping
- We propose and developed:
  - A study of statistical properties of DWI data
  - One statistical segmentation tool
  - A validation framework
  - Comparison to previous works

Methods

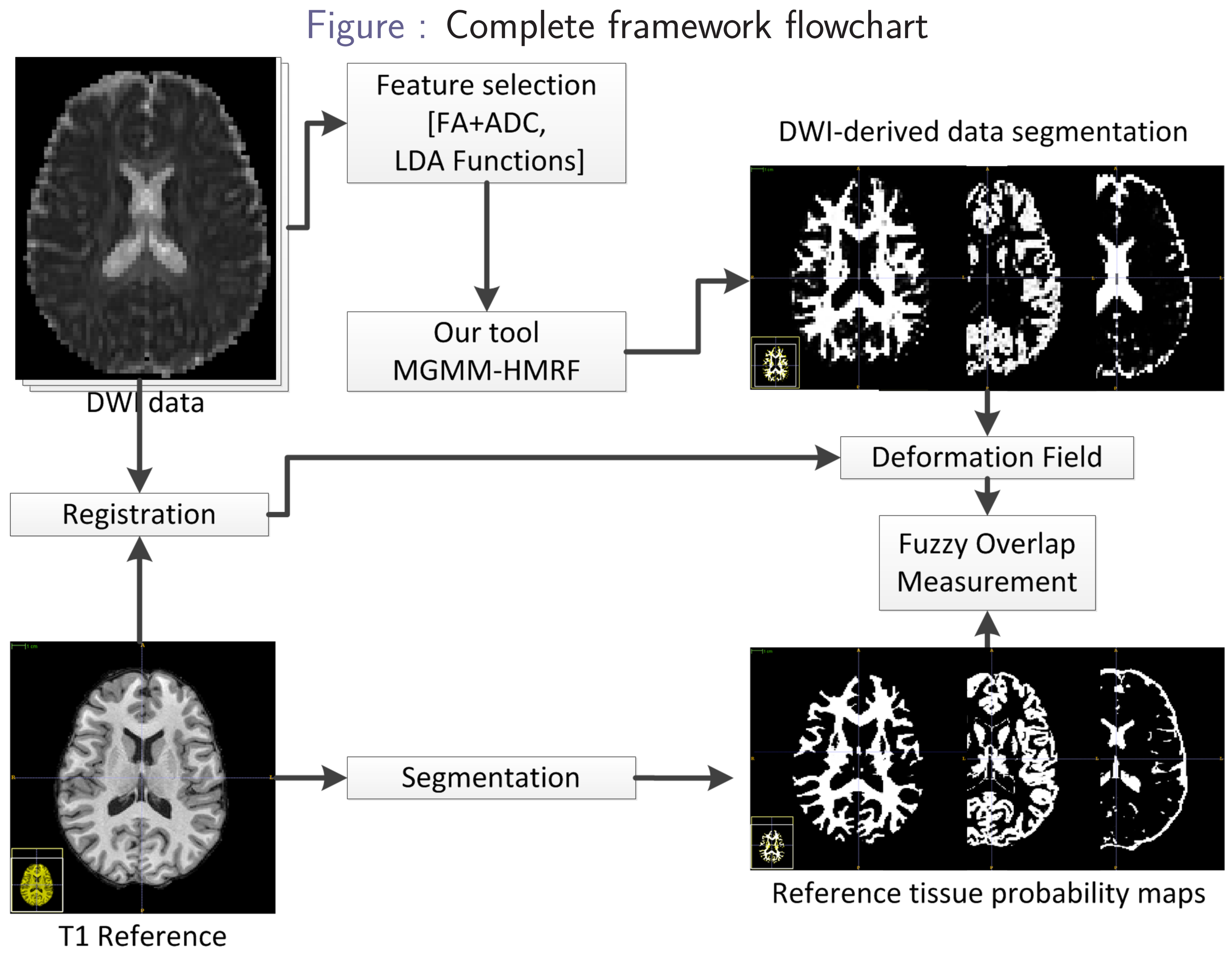
- Preliminar study on manually labeled samplings:
  - PCA: two *families* of maps
  - LDA: *discriminant* maps
  - Result: dimensionality & map selection



- Segmentation tool
  - Multivariate Gaussian Mixture Model (MGMM)
  - K-Means initialization (ITK based)
  - E-M optimization (ITK based)
  - Markov Random Field (MRF) using Graph-Cuts (GC)
    - α-Expansion or $\alpha\beta$-Swap available
    - maxflow-mincut algorithm from [1]
- Validation: fuzzy Jaccard index [2]:

$$TC = \frac{\sum_{\forall k} \alpha_k \sum_{\forall i \in \mathcal{S}} \min(P(x_i = l_k), P(\hat{x}_i = l_k))}{\sum_{\forall k} \alpha_k \sum_{\forall i \in \mathcal{S}} \max(P(x_i = l_k), P(\hat{x}_i = l_k))}$$

Figure : Complete framework flowchart



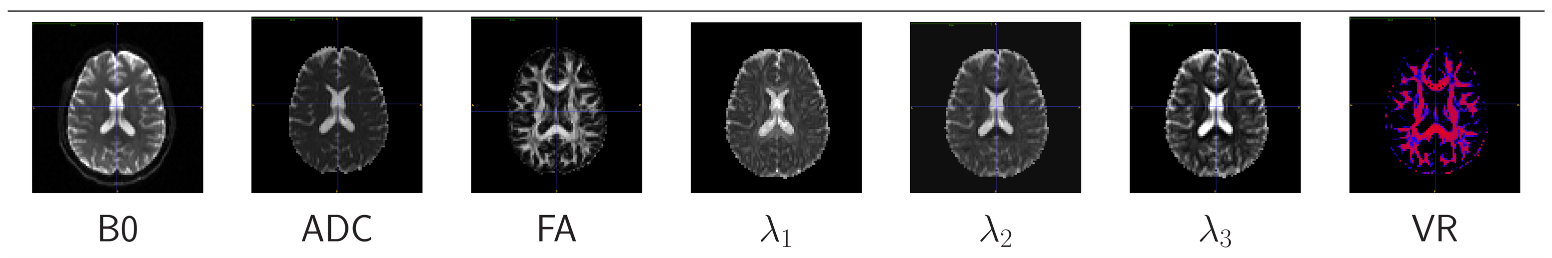
Conclusions

- Bivariate model with selected maps is reliable and accurate
- Previous works [3, 4] propose the fusion of univariate clusterings
  - Only for DTI (not DSI,QBI,HARDI,etc.)
  - No probabilistic results are provided by these methods
- The use of GC speeds up convergence of MRF and increases robustness
- Future lines:
  - Study the inclusion of PVE and its impact on overall performance and results
  - Update the framework with more evolved algorithms (variational inference)
  - Release the code

Dataset

Subjects	Modality	Vol/Subj	Resolution (mm)	Size (voxels)
6	DTI	2 × 63	2.21×2.21×3.00	96×96×34
	T1	1	1.00×1.00×1.20	240×256×260
1	DSI	1 × 515	2.21×2.21×3.00	96×96×44
	T1	1	1.00×1.00×1.20	240×256×260

- DWI-derived scalar maps:
  - DTI: B0, FA, ADC, AD, TR, PD$_1$, PD$_2$, PD$_3$, RD, λ_1 , λ_2 , λ_3
  - DSI: B0,gFA,aADC,asADC,afADC,kurtosis,skewness,P0
  - No fieldmappings were acquired for any case



Results

- PCA & LDA:
  - Non-hyperspherical distributions
  - Map selection: FA+ADC (DTI), gFA+aADC (DSI)
  - LDA functions
- Final benchmarks and comparison
  - Better than [4] and mFAST
  - LDA functions useless

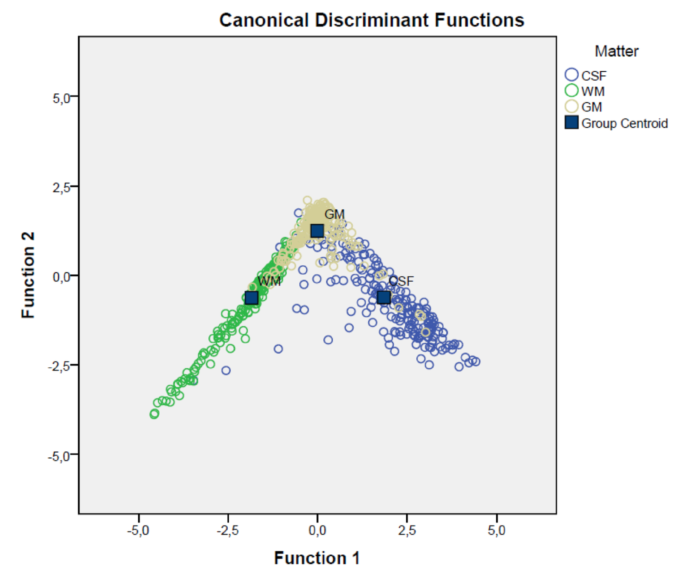


Figure : Joint histogram of FA and ADC. In white, iso-contours of the fitted MGMM

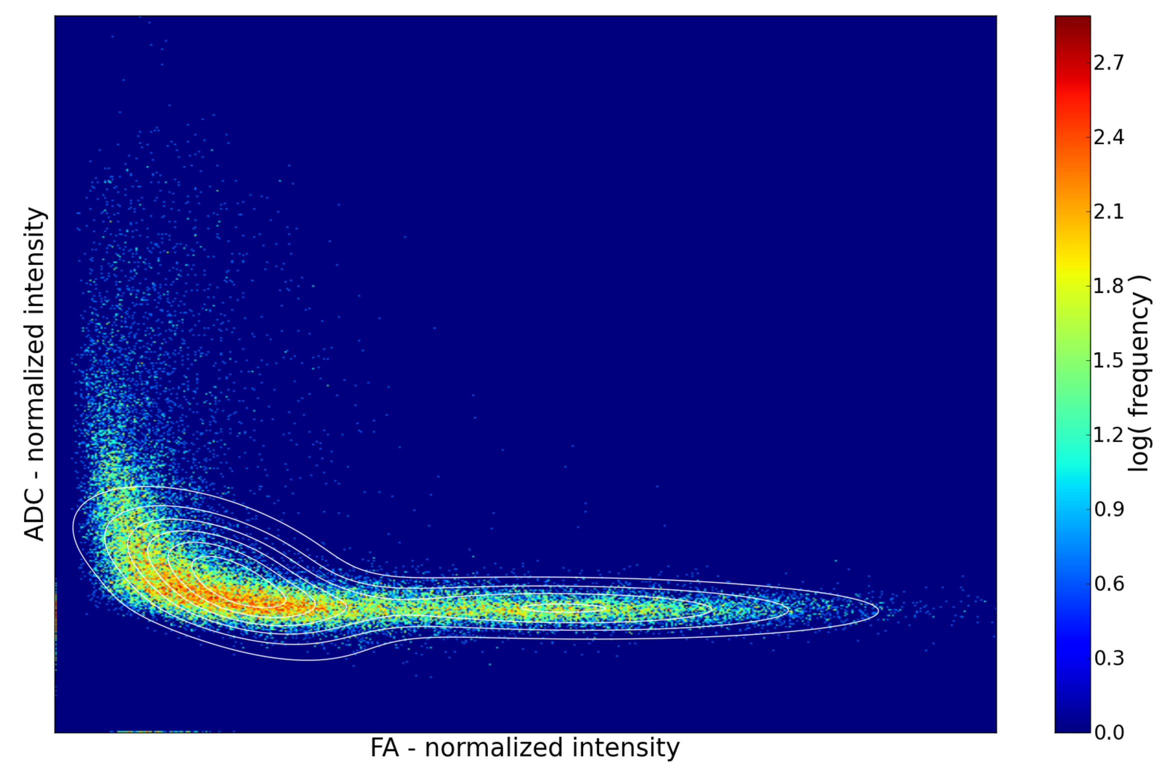


Figure : Liu et al.[4]

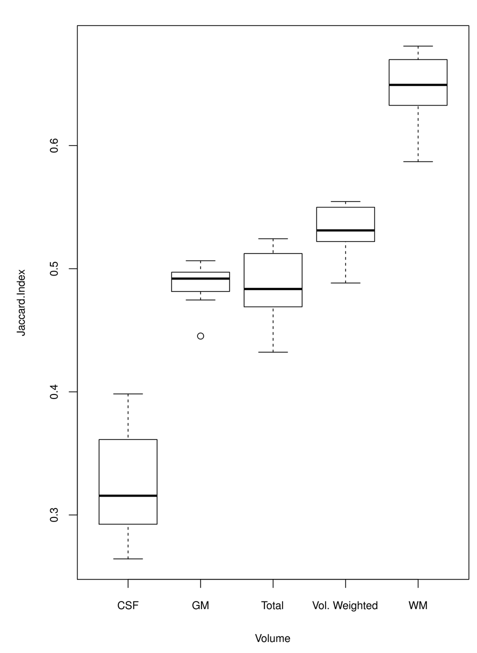


Figure : mFAST

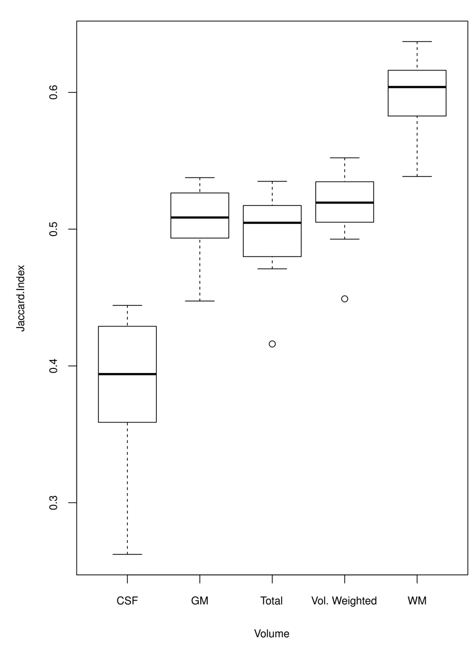
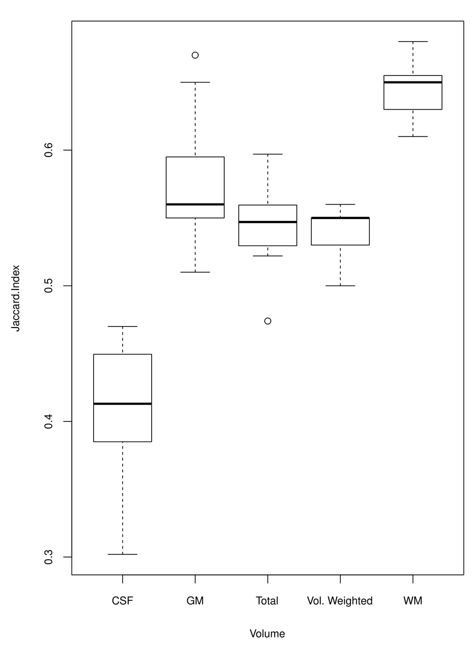


Figure : Presented tool



Acknowledgements and References

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